Journal of Advances and Scholarly Researches in Allied Education
Vol. 16, Issue No. 3, (Special Issue) March-2019, ISSN 2230-7540

Simulation of DG Systems Composed with Solar Photovoltaic and a Micro-Turbine in Remote Areas

Suryadeepsinh Jadeja[1]* Maulikkumar Chaudhari[2]

[1] PG Scholar, Electrical Department, GEC-Bhuj, Gujarat, India

[2] Assistant Professor, Electrical Department, GEC-Bhuj, Gujarat, India

Abstract – Rapid depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to cater to the present days' demand. Nevertheless, the action of PV array is unsteady as there is instability of radiation and temperature, and hence it is compulsory to combined work with governable power generation unit to enhance the stability of the entire system. A micro grid distributed generation system based on direct current bus has been considered comprising of PV power generation unit, micro turbine power generation unit, DC-DC converter and inverter unit. The photovoltaic energy is vastly dependent on environmental condition such as ambient temperature and insolation. The limitation of above said system is overcome by integrating MTG system. Thus load voltage variation is found to be in the acceptable range. This Micro grid system can withstand the disturbance in the load as well as the climatic conditions, and nullifies the problems of these variations at the supply voltage. This micro grid topology gives good performance under change in insolation, ambient temperature and load variation. This proposed micro grid topology can be used for isolated power generation in standalone areas or remote isolated groups.

----------X----------

INTRODUCTION

Rapid depletion of fossil fuel resources on a worldwide basis has necessitated an urgent search for alternative energy sources to cater to the present days' demand. Therefore, it is imperative to find alternative energy sources to cover the continuously increasing demand of energy while minimize the negative environmental impacts Recent research and development of alternative energy sources have shown excellent potential as a form of contribution to conventional power generation systems. There is a huge potential for utilizing renewable energy sources, for example solar energy, wind energy, or micro-hydropower to provide a quality power supply to remote areas. The abundant energy available in nature can be harnessed and converted to electricity in a sustainable way to supply the necessary power demand and thus to elevate the living standards of the people without access to the electricity grid. The advantages of using renewable energy sources for generating power in remote islands are obvious such as the cost of transported fuel are often prohibitive fossil fuel and that there is increasing concern on the issues of climate change and global warming.

The disadvantage of standalone power systems using renewable energy is that the availability of renewable energy sources has daily and seasonal patterns which results in difficulties of regulating the output power to cope with the load demand. Also, a very high initial capital investment cost is required. Combining the renewable energy generation with conventional diesel power generation will enable the power generated from a renewable energy sources to be more reliable, affordable and used more efficiently. Solar and wind energy systems are being considered as promising power generating sources due to their availability and topological advantages for local power generations in remote areas. This Paper focuses on the combination of solar wind systems for sustainable power generation. The solar energy also varies with the hourly, daily and seasonal variation of solar irradiation. The wind turbine output power varies with the wind speed at different conditions. However, a drawback, common to solar irradiation and wind speed options, is their unpredictable nature and dependence on weather and climatic changes, and the variations of solar and wind energy may not match with the time distribution of load demand. This shortcoming not only affects the system's energy performance, but also results in batteries being discarded too early.

SOLAR PV WORKING

There are several types of solar cells. However, more than 90 % of the solar cells currently made worldwide consist of wafer-based silicon cells. They are either cut from a single crystal rod or from a block composed of many crystals and are correspondingly called mono-crystalline or multi-crystalline silicon solar cells. Wafer-based silicon solar cells are approximately 200 µm thick. Another important family of solar cells is based on thin-films, which are approximately 1-2 µm thick and therefore require significantly less active, semiconducting material. Thin-film solar cells can be manufactured at lower cost in large production quantities; hence their market share will likely increase in the future. However, they indicate lower efficiencies than wafer-based silicon solar cells, which mean that more exposure surface and material for the installation is required for a similar performance. A number of solar cells electrically connected to each other and mounted in a single support structure or frame is called a 'photovoltaic module'. Modules are designed to supply electricity at a certain voltage, such as a common 12-volt system. The current produced is directly dependent on the intensity of light reaching the module. Several modules can be wired together to form an array. Photovoltaic modules and arrays produce direct-current electricity. They can be connected in both series and parallel electrical arrangements to produce any required voltage and current combination.

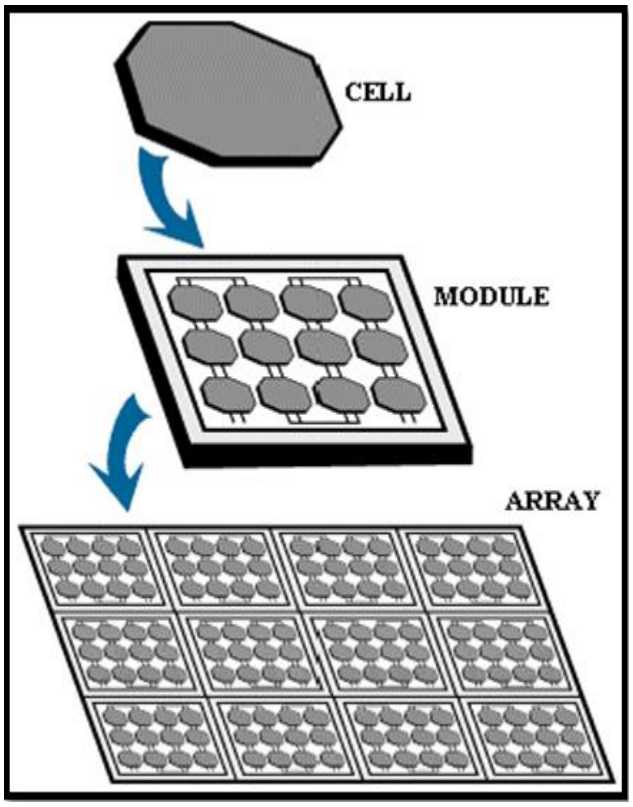


FIG. -1 ELECTRICAL CONNECTION OF THE CELLS

MICRO TURBINE

Micro Turbines are new type of combustion turbine used for stationary energy generation. The concept is evolved from automotive and truck turbochargers, auxiliary power units (APU) for airplanes. Approximately the size of a refrigerator with outputs of 25 kW to 500 kW. They provide not only electricity, but also the thermal energy to provide for all heating and cooling needs. Micro turbine producing power, as well as heat.

DESCRIPTION OF THE MICRO-TURBINE GENERATOR

The high speed PMSG generator, turbine, compressor, recupurators, and power electronics unit are the components of MTG system shown in Fig. 2

The MTG systems, works on the principle of the thermodynamic cycle generally called as the Brayton cycle. System presented here, in a radial compressor the inlet air is compressed and fed to the combustor. There the air which is compressed and mixed with oil and burned to produce high pressure combustion gas. This high pressure gas is then expanded on the turbine which is coupled to the electric generator (single shaft design). In order to increase the overall efficiency generally a micro turbine will have an air to gas heat exchanger. The heat exchanger utilizes the expanded gas to heat the compressed air prior it goes to combustion chamber so this will ultimately decreases the fuel consumption during the combustion process.

A PMSG (Permanent Magnet Synchronous generator is a high speed generator. This is usually used in the single shaft design. The output of PMSG is high frequency voltage (in kHz) and needed to convert this high frequency output voltage to 50Hz for normal application. Thus rectifier unit is used to convert high frequency output to DC and then converting to AC 50Hz. The presented model focuses on the slow changing aspects of the micro turbine generation system, this best suits for energy management of the MTG system collectively joined with other kinds of renewable energy systems. Thus, while exhibiting the MTG for the assumed purpose, the model is functioning under regular functioning conditions by ignoring fast changing aspects of the MTG like start-up, stoppage, inner faults and loss etc. The heat exchanger is only serves to improve the thermal efficiency of a MTG system which is not included in the model presented.

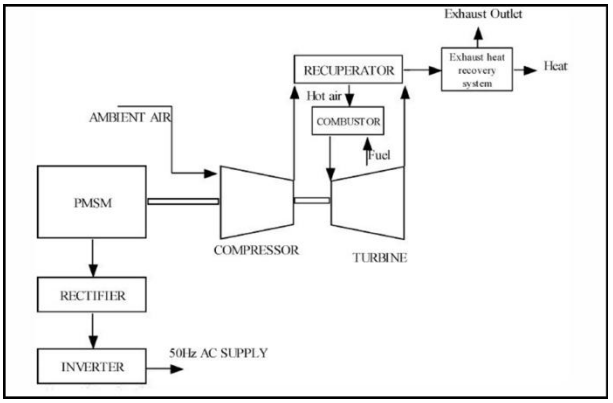


Fig. -2 Single-shaft micro turbine based generation system

HYBRID OPERATION AND SMART GRID

Hybrid Power Generation System

A typical hybrid system combines two or more energy sources, from renewable energy technologies such as PV-panels, wind or small hydro turbines; and from conventional technologies usually diesel Generator sets. In addition, it includes power electronics and electricity storage bank.

Our proposed hybrid system is designed for both on grid and off grid operation to reduce dependency on the national grid for electrical supply. The "fig." shows the block diagram of a typical hybrid grid connected power system. The system consists of PV generators, wind generator, biogas, biomass (rice husk), micro-hydro, battery bank, battery charge controller and the dump load.

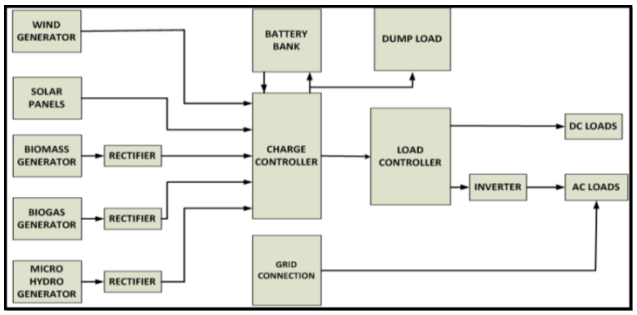
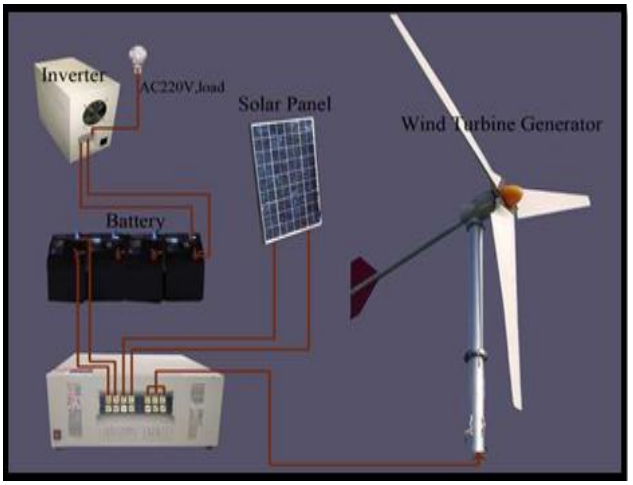
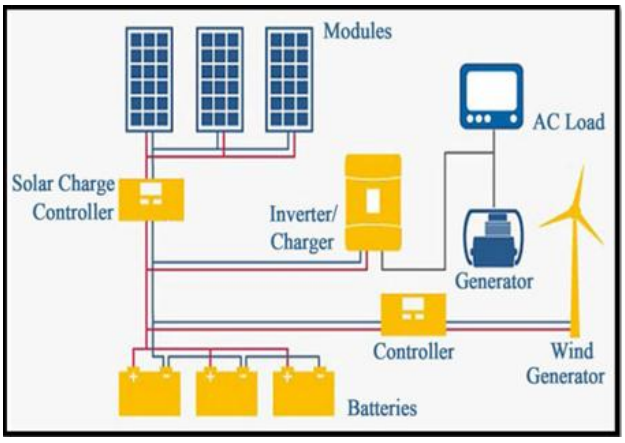


Fig. -3 Basic Diagram of Hybrid System

In this project a hybrid system of solar-wind is considered. Here, we have different power generating units. Some of them generate AC and others DC power directly.



(a)



(b)

Fig. -4 (a), (b) Solar-Wind Hybrid System

Grid Tie PV/ Micro turbine Hybrid System

These systems can be classified in terms of their connection to the power system grid into the following:

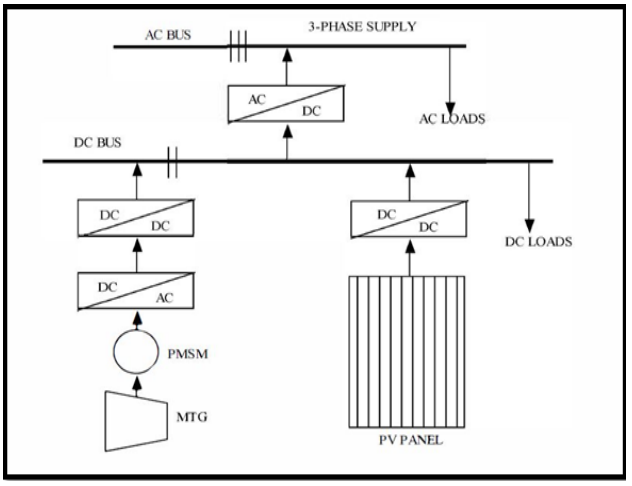


Fig. -5 Block diagram of the proposed system

Solar PV Simulation with MPPT

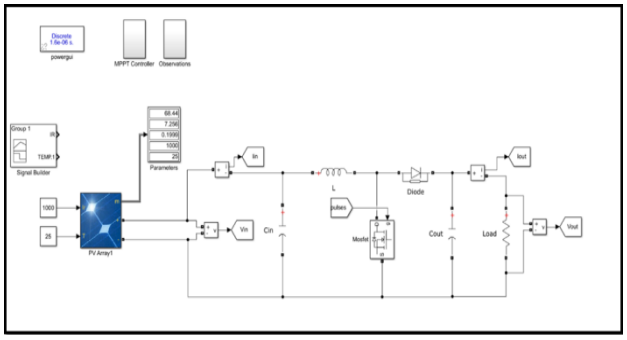


Fig. -6 Solar PV Array Simulation with MPPT & Boost Converter

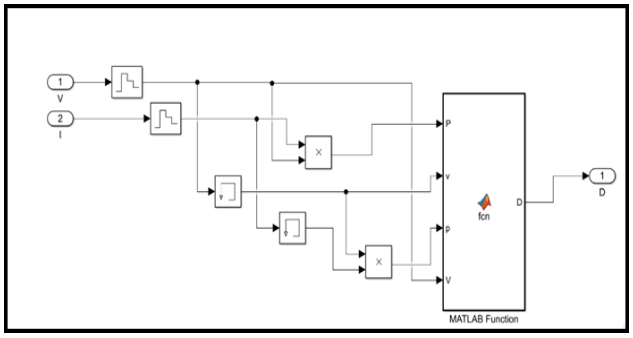


Fig. -7 MPPT Subsystem of for the Solar PV

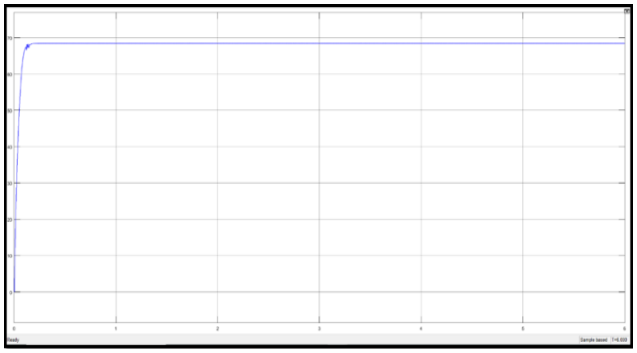


Fig. -8 Solar Input Voltage to Boost converter

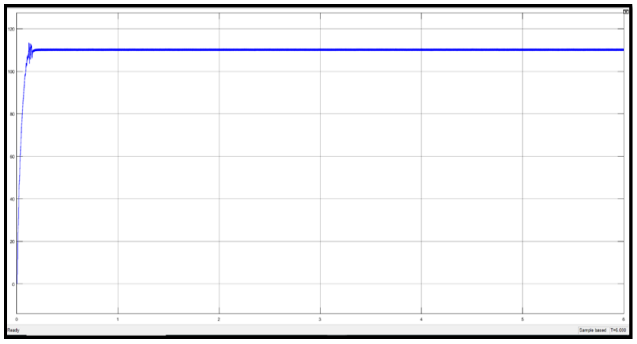


Fig. -9 Solar Output voltage from Boost converter

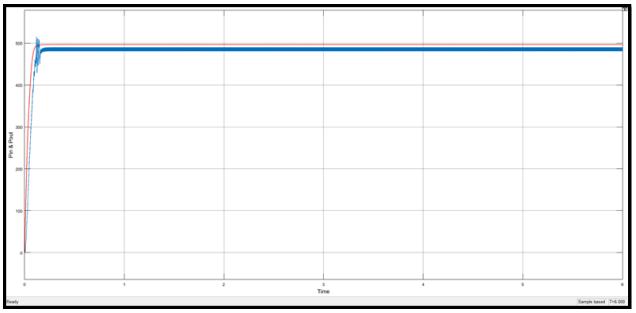


Fig. -10 Solar PV array Maximum power tracking using MPPT

PMSG based wind power plant simulation for micro turbine control

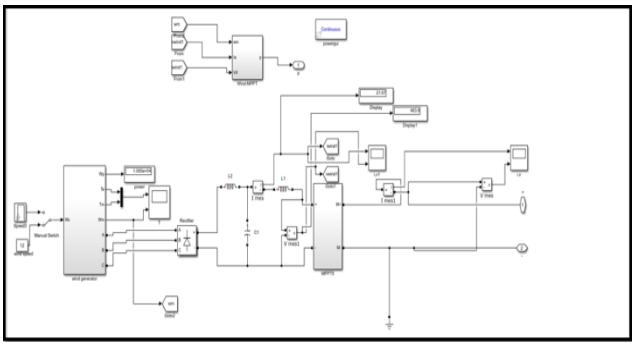


Fig. -11 Wind Simulation with MPPT

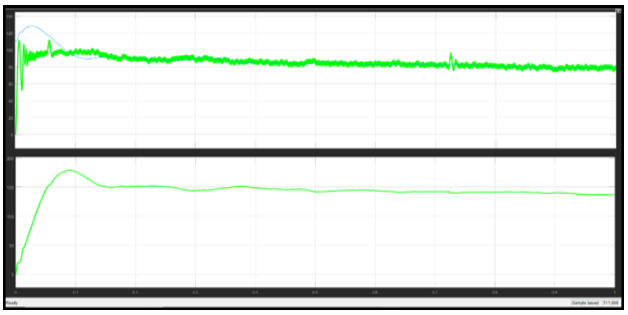


Fig. -12 wind Output variation in Mechanical Torque and electrical Power and Constant d.c Voltage

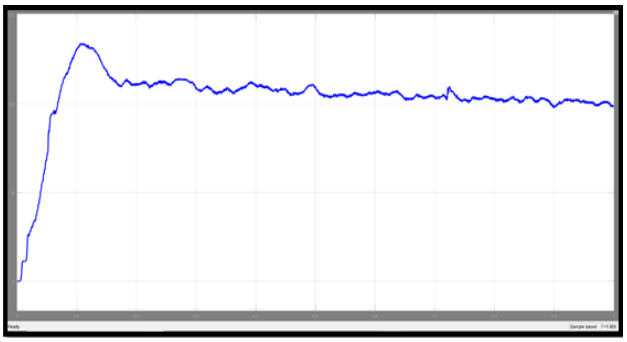


Fig. -13 Wind Output Constant D.C Voltage

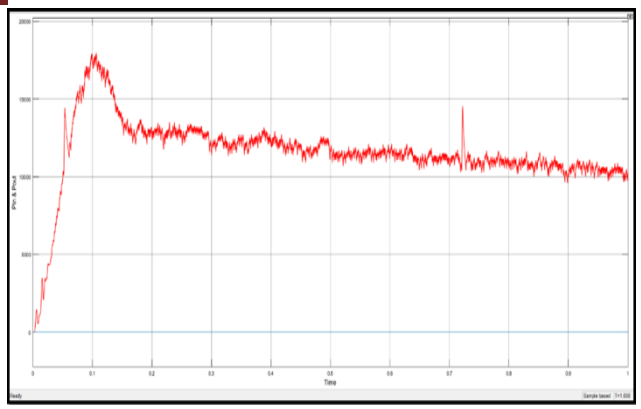


Fig. -14 Wind Maximum powers tracking using MPPT

Hybrid of Solar and PMSG based wind power plant for micro turbine control Using V_L-V_P Control Method

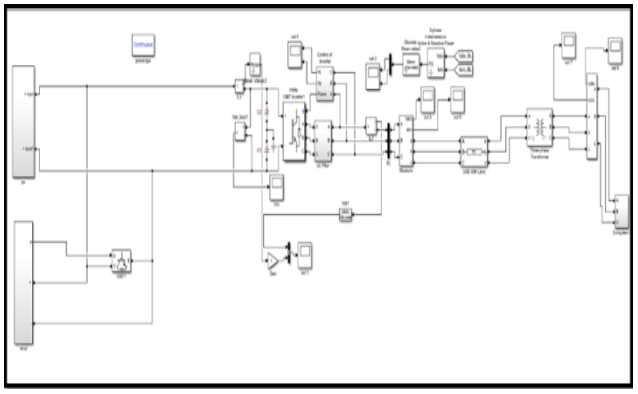


Fig. -15 Hybrid of Proposed Solar PV and Wind with Line and Phase voltage control method

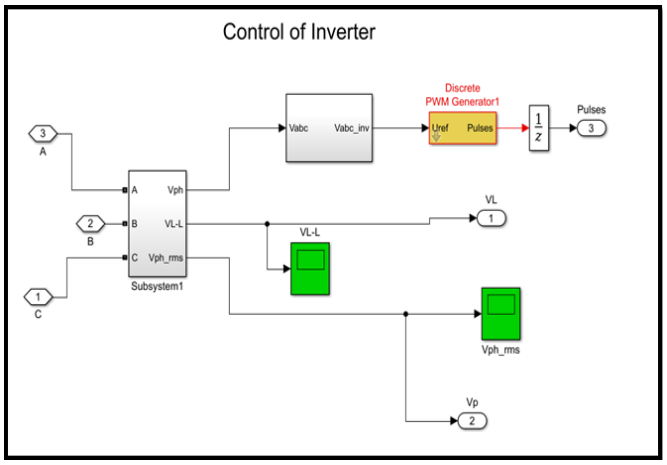


Fig. -16 Inverter Control Subsystem

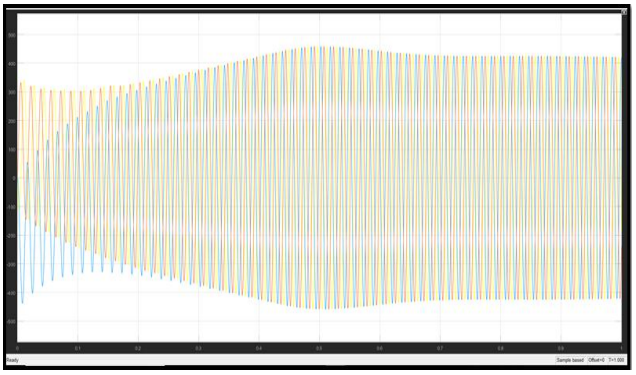


Fig. -17 Hybrid A.C output current of Solar-Wind

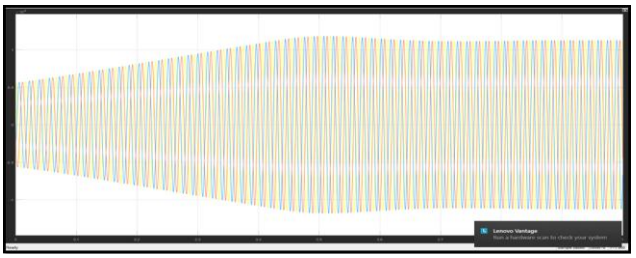


Fig. -18 Grid Side Synchronized Output Voltage

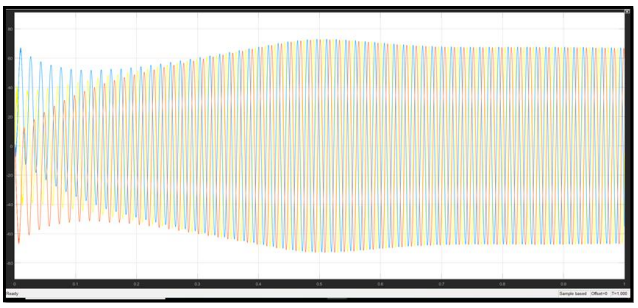


Fig. -19 Grid Side Synchronized output current

CONCLUSION

This paper presents a hybrid wind/PV energy system for standalone system. The available power from the renewable energy sources is highly dependent on the environmental condition such as radiation, ambient temperature etc. To overcome this deficiency of the solar module, it is integrated with the micro turbine generation system. The integrated system generates and supplies matching power in sustainable manner. This Project represents the modelling and Simulation of Solar PV System with MPPT boost controller using MATLAB-SIMULINK software. So, we can conclude that without MPPT boost converter combination, it is very difficult to obtain a smooth output and maximum power. To achieve maximum power point, we can control the current or regulate the voltage to maintain the power. Here, MPPT regulates the duty cycle to maintain voltage and achieve maximum power. The PMSG based Wind Power Plant Simulation for Micro Turbine control is also done using Matlab-Simulink. The PMSG based Wind Power Plant Simulation for Micro

Turbine control and its three-phase output voltage also show in the simulation results. The grid integration and synchronization of Solar and the PMSG based Wind Power Plant for Micro Turbine control Hybrid system has been successful done in this project.

REFERENCES

1. Siddaraj U. and Swathi Tangi (2016). "Integration of DG Systems Composed of Photovoltaic and a Micro-turbine In Remote Areas", International Conference on Computation of Power, Energy Information and Communication (ICCPEIC)©2016 IEEE

2. Basavaraj Shalavadi, Ravindranadh V., Uday Kumar R.Y. (2017). "Modelling and Analysis of A Standalone PV/Micro Turbine Hybrid System", International Conference on Innovative Mechanisms for Industry Applications (ICIMIA 2017)©2017 IEEE.

3. Modeling and Control for Smart Grid Integration of Solar/Wind Energy Conversion System, E. M. Natsheh, Member, IEEE, A. Albarbar, Member, IEE, and J. Yazdani, Member, IEEE

4. Modeling and Control for Smart Grid Integration with MPPT of Solar/Wind Energy Conversion System S. Sathish Kumar1 , B.Swapna2 , Dr.C.Nagarajan3 Research Scholar, GRT Institute of Engineering & Technology, Tamilnadu, India1 Assistant Professor, Dept. of EEE, GRT Institute of Engineering & Technology, Tamilnadu, India2 Professor, Dept. of EEE, Muthayammal College of Engineering, Tamilnadu, India

5. Hybrid Energy System and its Modelling in Smart Grid S.Ganesh kumaran#1 , Dr.S.Singaravelu* 2 , K.vivekanandan.

6. Smart Grid Technologies Simulation Experience at Russky Island, A. Grobovoy, Member IEEE, A. Arestova, M. Khmelik, V. Shipilov, and Y. Nikitin

7. Smart Grids Technology Fundamentals-New Course Adel El Shahat Georgia Southern University, aahmed@georgiasouthern.edu Rami Haddad Georgia Southern University, rhaddad@georgiasouthern.edu Youakim Kalaani Georgia Southern University, yalkalaani@georgiasouthern.edu

8. Dynamic performance analysis of an integrated windphotovoltaic microgrid with storage, Lawrence K. Lettinga*, Josiah L. Mundaa, Yskandar Hamama a Tshwane University of Technology, Pretoria, South Africa

9. Maximum Power Generation by Integrating Solar & Wind System Using Fuzzy for Voltage Regulation in Smart Grid Priya N.1 , Saranya C .M.2 Department of Power System Engineering, Valliammai Engineering College, Chennai, India

10. Dynamic Modeling, Control and Simulation of a Wind and PV Hybrid System for Grid Connected Application Using MATLAB D. Mahesh Naik1 , D. Sreenivasulu Reddy2 , Dr. T. Devaraju3 1 (PG Student, Dept. of EEE, Sree Vidyanikethan Engineering College, Tirupati, Andhra Pradesh, India) 2 (Assistant Professor, Dept. of EEE, Sree Vidyanikethan Engineering College, Tirupati, Andhra Pradesh, India) 3 (Professor & HOD, Dept. of EEE, Sree Vidyanikethan Engineering College, Tirupati, Andhra Pradesh, India)

11. Modeling and control of MPPT Based Grid Connected Wind-PV Hybrid Generation System S.Chandra Shekar PhD Scholar, Electrical and Electronics Engineering, Koneru Laxmaih University, Vijayawada, India, K.Raghu Ram Professor, Laqshya Institute of Technology and Sciences, Khammam, India

12. Systems and Control Opportunities in the Integration of Renewable Energy into the Smart Grid ? E. Bitar ∗ P. P. Khargonekar ∗∗ K. Poolla ∗∗∗∗ E. Bitar is with the Department of Mechanical Engineering, U.C. Berkeley ebitar@berkeley.edu (corresponding author) ∗∗ P.P. Khargonekar is with the Department of Electrical and Computer Engineering, University of Florida ppk@ece.ufl.edu ∗∗∗ K. Poolla is with the Department of Electrical Engineering and Computer Science, U.C. Berkeley poolla@eecs.berkeley.edu

13. Modeling Grid Connection for Solar and Wind Energy P. J. van Duijsen, Simulation Research, The Netherlands Frank Chen, Pitotech, Taiwan

14. Simulation of A Solar and Wind Hybrid System Representating Distributed Fed Generators In Evolving Grids For Renewable System Kishan patel Department of Electrical Engineering, Merchant Engineering College, Basna

15. Modeling and Simulation of Photovoltaic Module and Array based on One and Two

Diode Model Using Matlab/Simulink Ahmed Bouraiou a,b,*, Messaoud Hamoudaa, Abdelkader Chakerb, Mohammed Sadoka, Mohammed Mostefaouia, Salah Lachtar.

Corresponding Author

Suryadeepsinh Jadeja*

PG Scholar, Electrical Department, GEC-Bhuj, Gujarat, India